ON GEOMAGNETIC FLUCTUATIONS IN REGIONS REMOTE FROM HIGH-ALTITUDE NUCLEAR BURSTS

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~~It is the purpose of this letter to~~ ~~suggest~~ suggested that ionospheric ionization caused by beta particles resulting from the decay of detonation-produced neutrons is capable of causing a~~n~~ artificial geomagnetic solar flare effect (s.f.e.) ~~(~~[illegible]~~)~~ in regions several thousands of kilometers from a high-altitude nuclear burst. Although geomagnetic fluctuations due to a bomb-produced s.f.e. were noted in the Pacific following the Hardtack detonations, ~~(McNish, 1959), we refer here to~~ smaller disturbances occurr~~ing~~ed much further from the bursts. ~~The~~ Concepts ~~advanced~~ by Crain and Tamarkin (J Geophys Res 66: 35-39, 196 ~~(1961)~~), ~~which should be consulted for an explanation of much of what follows,~~ are used to make estimates concerning the characteristics of this effect. Comparisons with some experimental results are also made.

Geomagnetic fluctuations following the Orange detonation were observed at Palomar and Isabella in Southern California, and Resolute Bay in the Arctic. ~~(Benioff, as reported by Hodder, (1961))~~. These stations were all sufficiently remote from ground zero so as to preclude the possibility of effects due to direct or scattered radiation. ~~Also, the onset times were too rapid to be explicable on the basis of~~

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slowly propagating hydromagnetic phenomena. (The announced time for Orange was August 12, 1958, at 10:30:08 GMT (AEC, 1959) and Benioff's measurements show fluctuations beginning several tenths of a second after this.) The disturbances were "fractional gamma" in magnitude, and were mainly in the horizontal components of the earth's field.

Typical onset times of ionization due to neutron-decay betas can be estimated to be the order of tenths of a second for a burst-observer distance of a few thousand kilometers. This is in qualitative agreement with the above-quoted measurements. Also, investigations not reported here show that neutrons originating in excess of approximately twenty or thirty kilometers above Johnston Island would have access to geomagnetic field lines passing through the Southern California and Resolute Bay stations.

The persistent ionization produced by neutron-decay betas should lie in the upper D and lower E regions, which is the altitude range in which the current sheets responsible for geomagnetic fluctuations are generally assumed to exist. An order of magnitude estimate of the size of the resulting artificial s.f.e. can be made by noting that the strength of a magnetic disturbance is approximately proportional to the overhead current strength and hence the overhead ionization density. (This is, of course, oversimplified as height variations in the ionization and the collision frequency also play a role.) Thus, if the ambient, local ionization density, N_o, corresponds to a local sq magnetic fluctuation, ΔH_o, then a bomb-induced additional ionization, δn, will produce a geomagnetic fluctuation, δH, which is given approximately by

$$\delta H \sim \frac{\delta n}{N_o} \Delta H_o \cdot \qquad (1)$$

ΔH_o is available as a function of local time and geomagnetic latitude in various references (e.g., Critical Tables, 1929). δn depends on the positions of the detonation and observation points, and is approximately proportional to the bomb yield. It can be conservatively estimated (Crain and Tamarkin, 1961) that an average of some 50 ion-pairs per cc could be formed in a layer of atmosphere 20 km thick and covering about half the earth in 1 second following the detonation of 1 megaton of fission yield. If this figure is taken as typical, δn may be estimated to be the order of 100 ion-pairs per cc for a weapon in the megaton range such as Orange. An average value for N_o of a few thousand electrons per cc is reasonable for the altitudes in question under nighttime conditions, and ΔH_o can be found from the preceding reference to be a few gamma in Southern California at the time of Orange. An insertion of these numbers in Eq. (1) indicates that δH would be the order of tenths of a gamma in Southern California following Orange. This is quite compatible with the observed fractional gamma magnitudes.

We mention in conclusion that the persistence time of ionization has been examined, and at this point we are unable to explain the fact that the fluctuations appear to have lasted for only a few seconds. Their small amplitude relative to the background noise could be a factor, however.

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